HOW DO STUDENT OUTCOME EVALUATION CRITERIA CORRELATE WITH EACH OTHER?

Wen Cheng, College of Engineering, California State Polytechnic University-Pomona, 3801 W. Temple Ave, Pomona, 91768, 909-869-2957, wcheng@cpp.edu
Gurdiljot Gill, College of Engineering, California State Polytechnic University - Pomona, 3801 W. Temple Ave, Pomona, 91768, 909-908-7084, gurdiljotg@cpp.edu
Xudong Jia, College of Engineering, California State Polytechnic University - Pomona, 3801 W. Temple Ave, Pomona, 91768, 909-869-2931, xjia@cpp.edu

ABSTRACT

Efficient evaluation of student outcomes plays an important role in the continued improvement of an Engineering program. The study aims to explore whether there exist any correlation among eleven different student outcomes based on student responses to senior exit survey. Using Pearson product-moment correlation coefficient calculated by statistical software R, the results demonstrate that positive correlation exists among all student outcomes, while some of them have a stronger association, and some others have a relatively small correlation.

INTRODUCTION

Efficient evaluation of student outcomes plays an important role in continuous improvement of any engineering program. Given the importance of student outcome assessment, Criteria for accrediting engineering programs 2016-2017 [1] recently published by ABET (Accreditation Board for Engineering and Technology) provide clear definitions of various student outcomes shown as shown in Table 1.

TABLE 1. Various Student Outcomes Defined by ABET

Student Outcomes	Definition
a	an ability to apply knowledge of mathematics, science, and engineering
b	an ability to design and conduct experiments, as well as to analyze and interpret data
c	an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d	an ability to function on multidisciplinary teams
e	an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
f	an understanding of professional and ethical responsibility
g	an ability to communicate effectively
h	the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

i	a recognition of the need for, and an ability to engage in life-long learning
j	a knowledge of contemporary issues
k	an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Various methods have been illustrated in literature for assessment of student outcomes which include, but not limited to, in-classroom assessment [2], analysis of specially designed industrial survey [3], and statistical analysis for identification of differing influential factors [4], and so on. As one of the largest Civil Engineering programs in the US with 1300+ enrolled undergraduates and 200+ graduate students, California State Polytechnic University, Pomona (or, CPP) has implemented different strategies to assess students' learning outcomes based on the national-level Engineering in Training Licensing Exams, Senior Exit Survey, Graduation Writing Test, Senior Project Symposium, etc. Amongst them, senior exit survey requires the students about to graduate to conduct self-evaluation in response to a large number of questions which include the performance assessment of 11 outcomes as displayed in Table 1. Therefore, the Senior Exit Survey furnishes the Department of Civil Engineering with a wealth of information from the students' perspectives regarding the student outcomes. Different from other typical assessment of student outcomes, the paper aims to explore whether there exists a correlation among the differing student outcomes on the basis of students' self-evaluation. It is anticipated that the curriculum or pedagogy strategies could be designed to target on the clustered outcomes should the correlation exist. The detailed information about the senior exit survey, data collected, and pertinent results are shown in the sections that follow.

DATA COLLECTION

Senior Exit Survey is routinely conducted at the Department with the target of the students close to satisfaction of all degree requirements. The information collected including student name, admission status, years spent at CPP, the level of participation in various professional societies or clubs, a senior project they join, and self-assessment of the 11 student outcomes, and so on. For each of the outcomes, students were asked to rate their capabilities on a scale of 1-5: (1) Poor; (2) Fair; (3) Average; (4) Good; (5) Excellent. In the period of 2014-15, the department collected 288 effective survey responses and the descriptive statistics are shown in Table 2.

TABLE 2. Descriptive Statistics of Responses to Self-Evaluation of Student Outcomes

Student Outcomes*	Excellent (5)	Good (4)	Average (3)	Fair (2)	Poor (1)	Rating Average**	Response Count
(a)	142	128	13	3	2	4.41	288
(b)	103	145	35	3	2	4.19	288
(c)	83	131	65	9	0	4.00	288
(d)	155	110	18	4	1	4.44	288
(e)	124	136	23	4	1	4.31	288
(f)	188	90	8	2	0	4.61	288
(g)	148	115	18	7	0	4.40	288

(h)	132	122	28	6	0	4.32	288
(i)	167	104	15	1	1	4.51	288
(j)	101	146	36	5	0	4.19	288
(k)	109	156	20	3	0	4.29	288

Notes: *: The detailed description of each student outcome can be found in Table 1.

**: The rating average is calculated based on the scale of 1-5. The higher the ratings, the better the performance.

METHODOLOGY AND RESULTS

As mentioned previously, the main objective of the research is to explore the correlation relationship among the set of student outcomes. In statistics, the most familiar measure of dependence between two quantities is the Pearson product-moment correlation coefficient, or "Pearson's correlation coefficient" [5], commonly called simply "the correlation coefficient". It is obtained by dividing the covariance of the two variables by the product of their standard deviations.

The population correlation coefficient $\rho_{X,Y}$ between two random variables X and Y with expected values μ_X and μ_Y and standard deviations σ_X and σ_Y is defined in Equation 1:

$$\rho_{X,Y} = \frac{cov(X,Y)}{\sigma_X \sigma_Y} = \frac{E[(X-\mu_X)(Y-\mu_Y)]}{\sigma_X \sigma_Y} \tag{1}$$

where E is the expected value operator, cov means covariance.

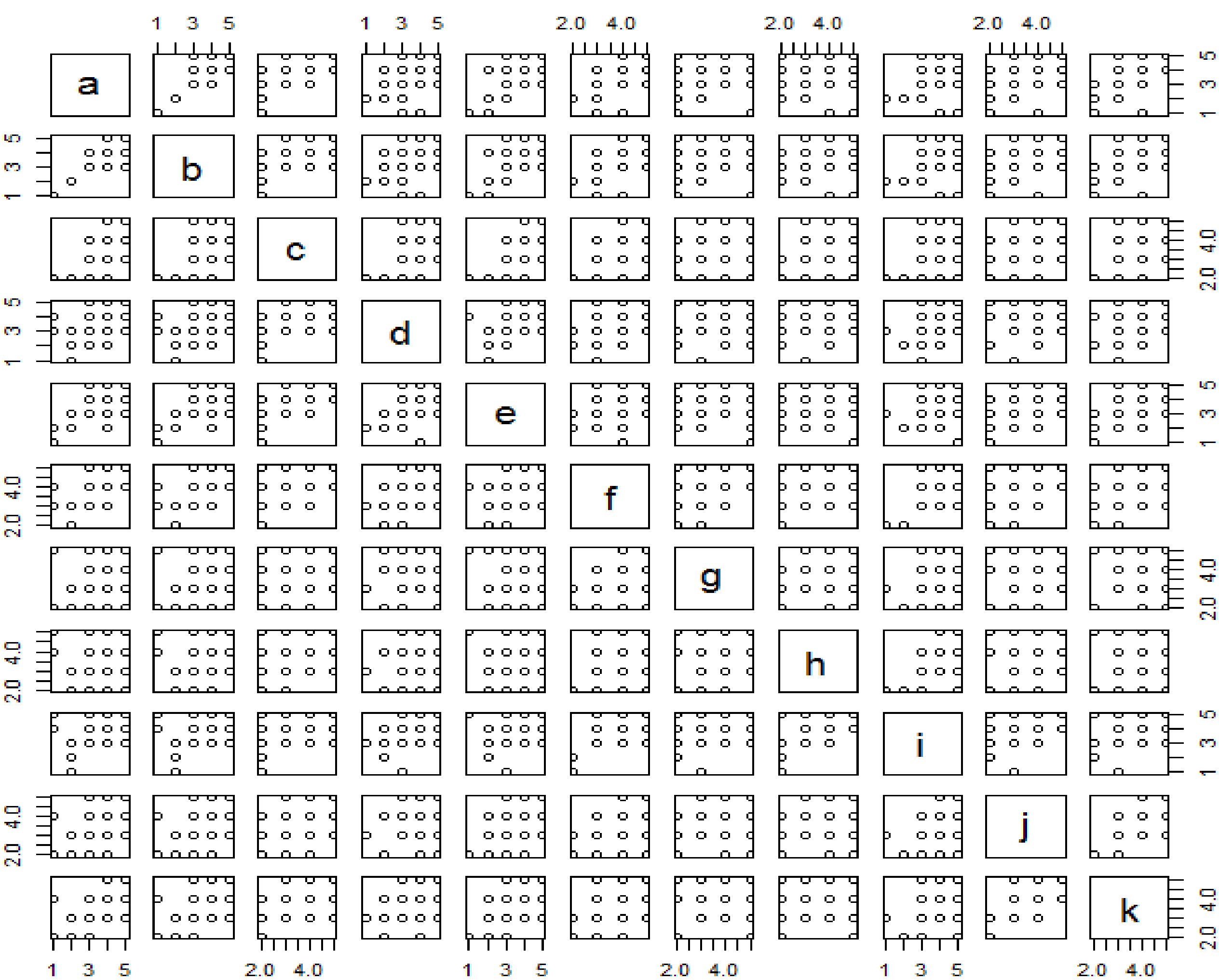
The Pearson correlation is +1 in the case of a perfect direct (increasing) linear relationship (correlation), −1 in the case of a perfect decreasing (inverse) linear relationship, and some value in the open interval (−1, 1) in all other cases, indicating the degree of linear dependence between the variables. As it approaches zero there is less of a relationship (closer to uncorrelated). The closer the coefficient is to either −1 or 1, the stronger the correlation between the variables.

Since the correlation is calculated between variables and there are 11 student outcome categories in the research study, there is a correlation matrix of 11x10. To furnish the correlation analysis, the authors employed the *Hmisc* Library of statistical software R [6] which can compute all correlation pairs at once.

FIGURE 1. Correlation Matrix Among Eleven Student Outcomes Evaluations

	a	b	c	d	e	f	g	h	i	j	k
a	1.00	0.70	0.52	0.48	0.70	0.50	0.39	0.35	0.38	0.31	0.57
b	0.70	1.00	0.62	0.48	0.66	0.43	0.38	0.42	0.42	0.42	0.57
c	0.52	0.62	1.00	0.49	0.61	0.41	0.38	0.47	0.40	0.48	0.58
d	0.48	0.48	0.49	1.00	0.55	0.49	0.47	0.44	0.46	0.41	0.46
e	0.70	0.66	0.61	0.55	1.00	0.48	0.44	0.38	0.43	0.42	0.62
f	0.50	0.43	0.41	0.49	0.48	1.00	0.54	0.56	0.59	0.42	0.45
g	0.39	0.38	0.38	0.47	0.44	0.54	1.00	0.48	0.46	0.40	0.39
h	0.35	0.42	0.47	0.44	0.38	0.56	0.48	1.00	0.64	0.59	0.52
i	0.38	0.42	0.40	0.46	0.43	0.59	0.46	0.64	1.00	0.58	0.48
j	0.31	0.42	0.48	0.41	0.42	0.42	0.40	0.59	0.58	1.00	0.60
k	0.57	0.57	0.58	0.46	0.62	0.45	0.39	0.52	0.48	0.60	1.00

FIGURE 2. Plot of Evaluation of Eleven Student Outcomes



Based on the Correlation matrix and plots, it is interesting to know that the student evaluations of the 11 student outcomes are all positively related to each other. Amongst them, the largest correlation (0.70) exist between student outcome (a & b) and (a & e), while the least correlation value (0.31) remains in the pair of (a & j). Such findings can be interpreted as an ability to apply knowledge of mathematics, science, and engineering seems to have a strong association with the ability to design and conduct experiments, as well as to analyze and interpret data, and the ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability, while it has less impact on students' knowledge of contemporary issues.

CONCLUSIONS

Based on 288 students' responses to senior exit survey, the study intends to explore the relationship among 11 student outcomes defined by ABET, which can shed more insight to teachers for their design of curriculum and pedagogy strategies aiming to enhance students' outcomes. The results illustrate that there exist positive correlation among all student outcomes, while some of them (such as a&b, and a&e) have a stronger association, and some others (such as a&j) have a smaller correlation.

ACKNOWLEDGEMENTS

The authors are indebted to all participating students' responses to senior exit survey conducted by the Civil Engineering Department of CPP.

REFERENCES

[1] Engineering Accreditation Commission. Criteria for accrediting engineering programs. Accreditation Board for Engineering and Technology Inc, 2016.

[2] Richter, D. M., & Paretti, M. C. Identifying barriers to and outcomes of interdisciplinarity in the engineering classroom. European Journal of Engineering Education, 2009, 34(1), 29-45.

[3] Kassim, H., & Ali, F. English communicative events and skills needed at the workplace: Feedback from the industry. English for Specific Purposes, 2010, 29(3), 168-182.

[4] Passow, H. J., Mayhew, M. J., Finelli, C. J., Harding, T. S., & Carpenter, D. D. FACTORS INFLUENCING ENGINEERING STUDENTS'DECISIONS TO CHEAT BY TYPE OF ASSESSMENT. Research in Higher Education. 2006, 47(6), 643-684.

[5] Francis, DP; Coats AJ; Gibson D. How high can a correlation coefficient be?. International Journal of Cardiology. 1999, 69 (2): 185–199. doi:10.1016/S0167-5273(99)00028-5.

[6] Mevik, B. H., & Wehrens, R. The pls package: principal component and partial least squares regression in R. Journal of Statistical software, 2007, 18(2), 1-24.